The Importance of Observations for Model Validation: Two Case Studies

14th International Workshop on Wave Hindcasting and Forecasting

November 12, 2015

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Coastal Data Information Program (CDIP)

Southern California Coastal Ocean Observing System (SCCOOS)

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TWO CASE STUDIES

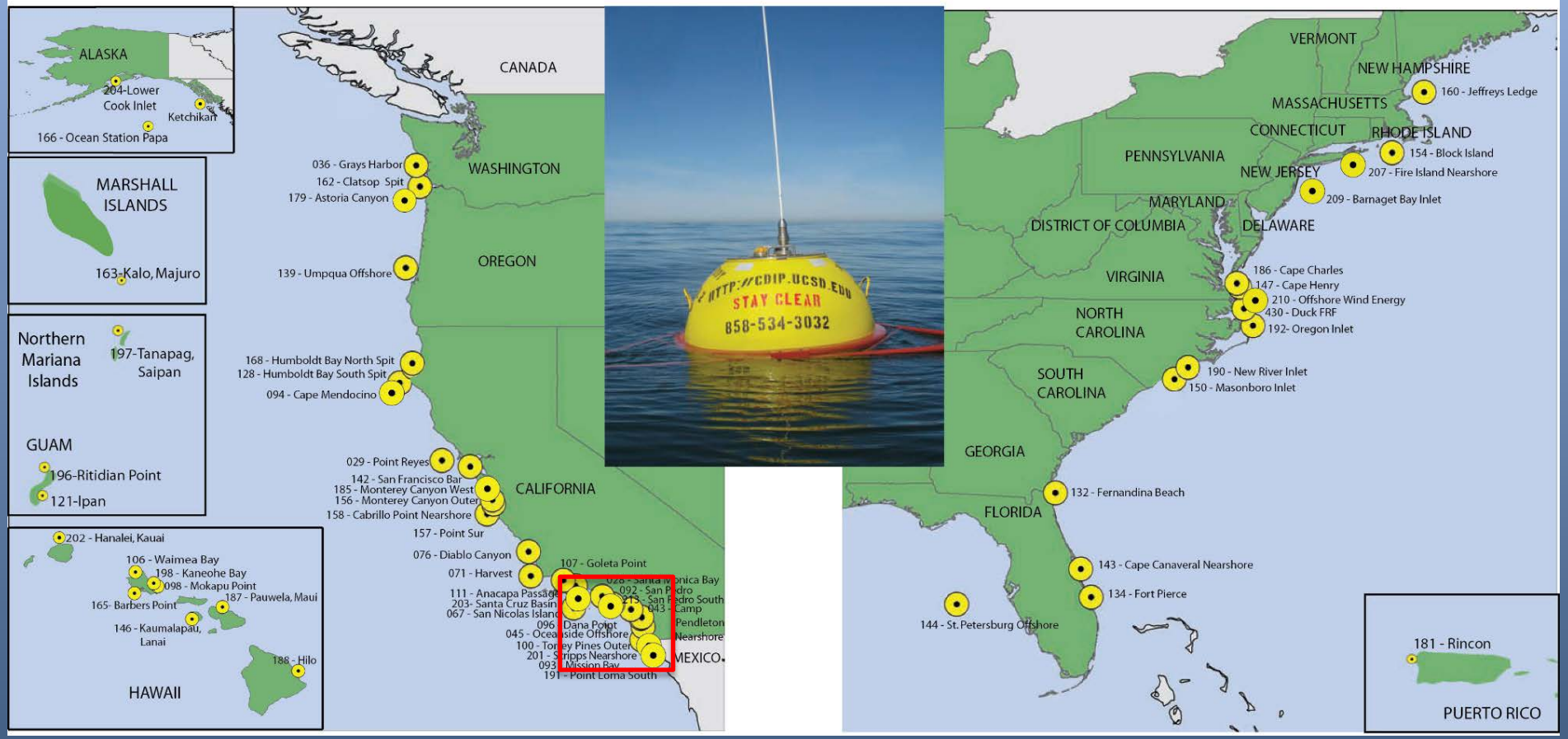
1. Precision Navigation Under Keel Clearance Project at the Port of Long Beach

2. 3 Day flooding index at Cardiff, Ca

The value of the observations and models for human safety, economics, and the environment.

COASTAL DATA INFORMATION PROGRAM

CDIP



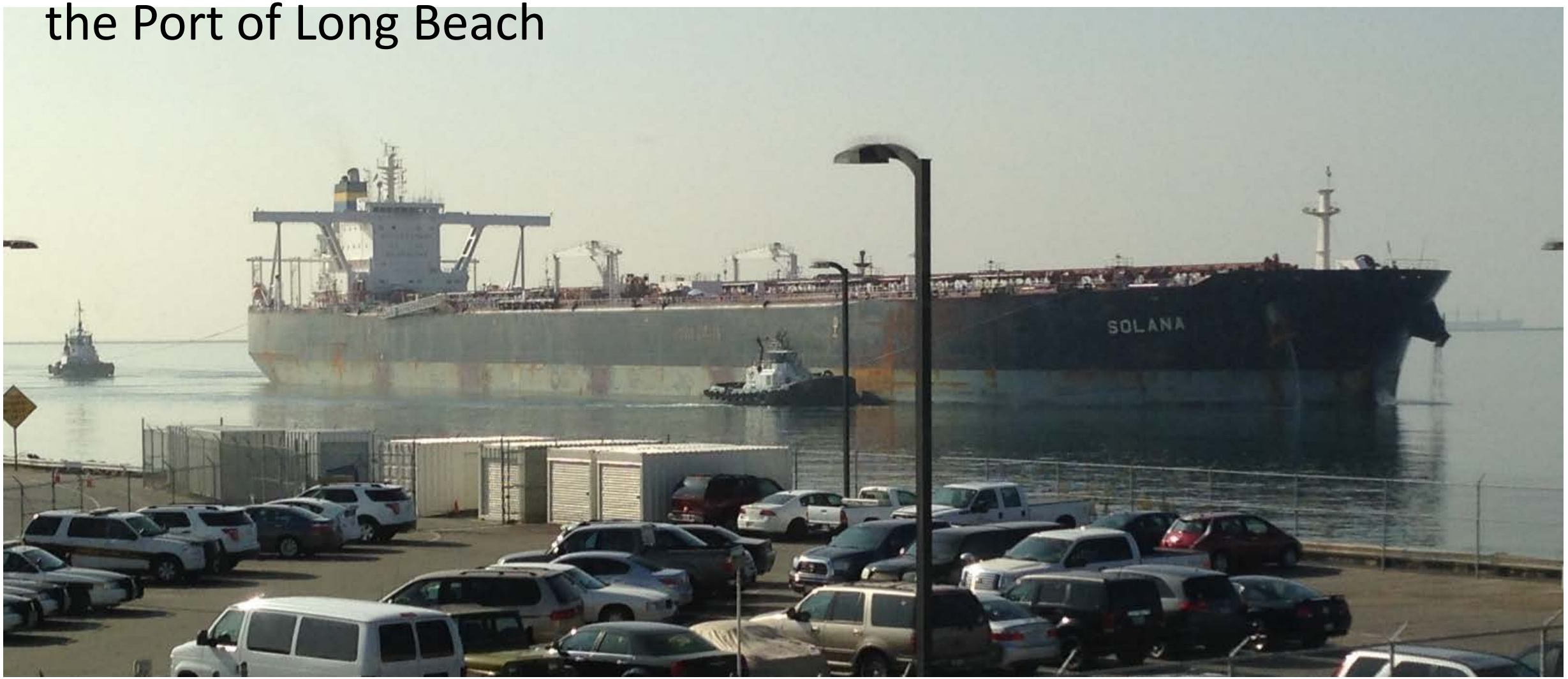
64 Active Stations Updated Every 30 Minutes.
cdip.ucsd.edu, ndbc.noaa.gov, sccoos.org

US Army Corps of Engineers

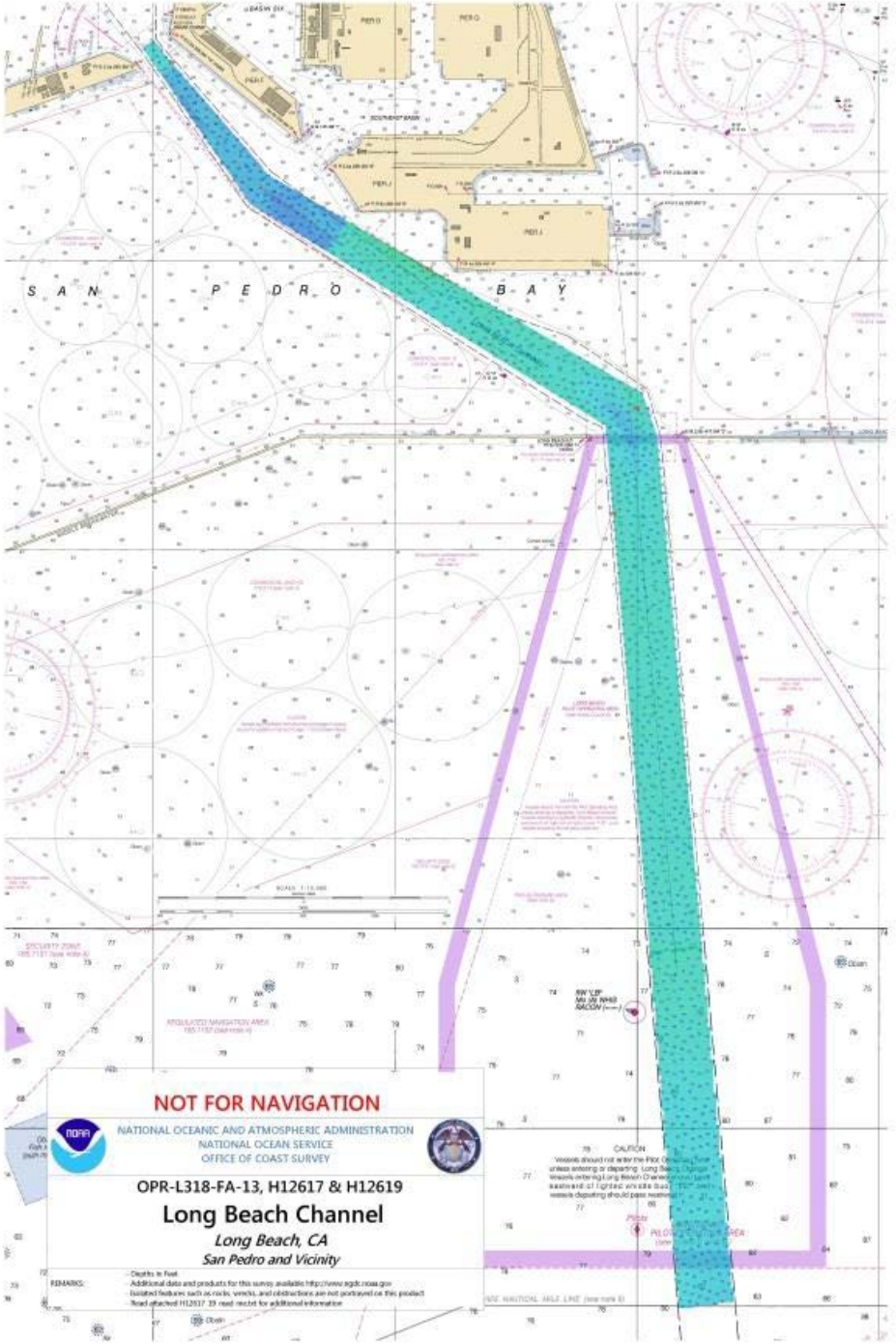
IOOS INTEGRATED OCEAN OBSERVING SYSTEM

CASE STUDY ONE: *Under Keel Clearance Project*

The Challenge: Very Large Crude Carriers (VLCCs) & ULCCs entering the Port of Long Beach



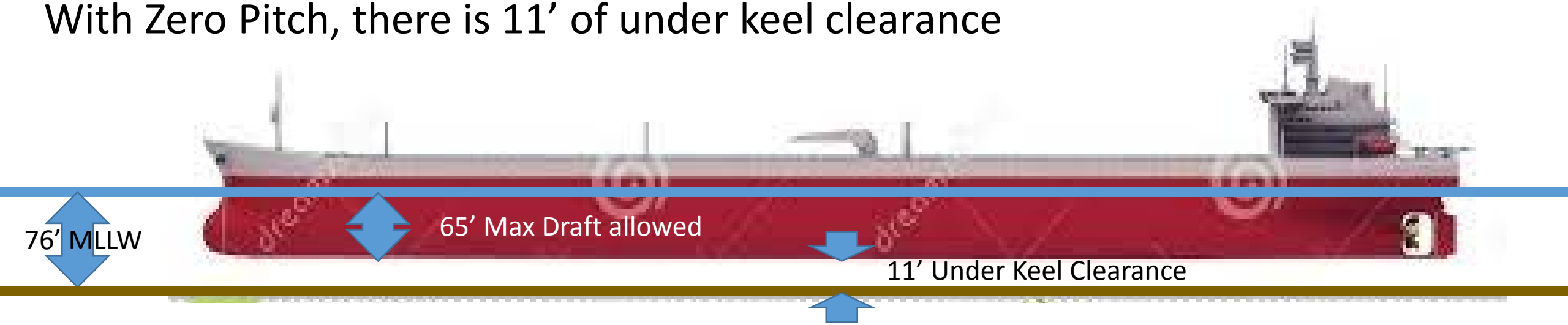
M/V ***Solana*** passing Jacobsen Pilot Station enroute pier 121, Tuesday 23 September 2014



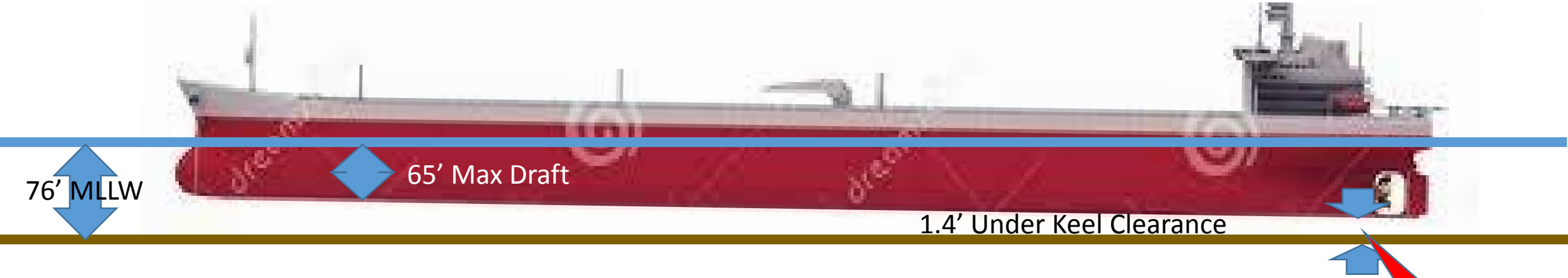
Approach to port of Long Beach…

Channel dredged to 76 feet

With Zero Pitch, there is 11’ of under keel clearance



With 1 degree of Pitch, there is a 9.6’ increase in draft for a 1,100 foot tanker:



WAVES ON THE STERN (FROM THE SOUTH) CAUSE THE VESSELS TO PITCH

1.4’ UKC!!

The Present:

GO/NO GO decision made using:

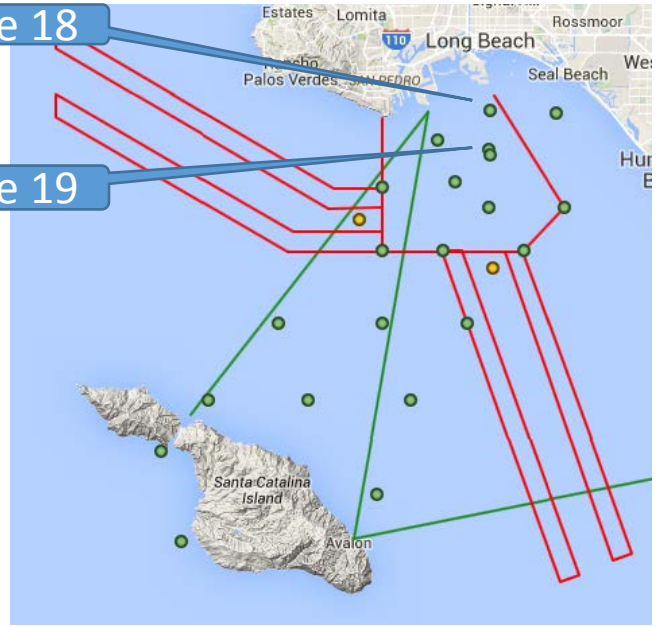
- ✓ CDIP Swell Warnings
- ✓ CDIP Buoy Reports
- ✓ Experience
- ✓ Seaman's Eye
- ✓ Observed pitch & roll far enough offshore to permit "bail-out" before committing to channel

Wed 9/9/2015 9:12 AM

CDIP Processing <uproc@model.cdip.ucsd.edu>

San Pedro Swell Warning

To nine_trk@cdip.ucsd.edu; Kip Louttit; Swell-alert@jacobsenpilot.com



Prediction site: SP018

Date (PST)	14+ Hs (ft)	14+ Tp (secs)	14+ Dp (deg T)	Tot Hs (ft)	Tot Tp (secs)	Tot Dp (deg T)
2015-09-09 01:00 pm	3.77	15.38	168	4.43	15.38	168
2015-09-09 04:00 pm	4.79	15.38	166	5.51	15.38	166
2015-09-09 07:00 pm	4.99	14.29	165	5.91	14.29	165
2015-09-09 10:00 pm	4.69	14.29	165	5.94	14.29	165
2015-09-10 01:00 am	4.20	14.29	167	5.81	14.29	167
2015-09-10 04:00 am	4.04	15.38	171	5.81	15.38	171
2015-09-10 07:00 am	4.17	15.38	172	6.07	15.38	172
2015-09-10 10:00 am	3.77	14.29	171	6.10	14.29	171
2015-09-10 01:00 pm	2.76	14.29	174	5.81	13.33	173

Link:
http://www.sccoos.org/data/harbors/lalb/mop_site.php?mop=SP018&page=fc_swell_plot&xperiod=14&tz=PST&units=english

Prediction site: SP019

Date (PST)	14+ Hs (ft)	14+ Tp (secs)	14+ Dp (deg T)	Tot Hs (ft)	Tot Tp (secs)	Tot Dp (deg T)
2015-09-09 01:00 pm	3.77	15.38	168	4.53	15.38	168
2015-09-09 04:00 pm	4.30	15.38	166	5.05	15.38	166
2015-09-09 07:00 pm	4.27	15.38	166	5.05	15.38	166
2015-09-09 10:00 pm	4.04	14.29	168	4.95	14.29	168
2015-09-10 01:00 am	4.00	14.29	170	5.18	14.29	170
2015-09-10 04:00 am	4.10	14.29	171	5.87	13.33	169
2015-09-10 07:00 am	4.27	14.29	171	6.76	13.33	169
2015-09-10 10:00 am	3.87	14.29	173	7.15	13.33	169

Link:
http://www.sccoos.org/data/harbors/lalb/mop_site.php?mop=SP019&page=fc_swell_plot&xperiod=14&tz=PST&units=english

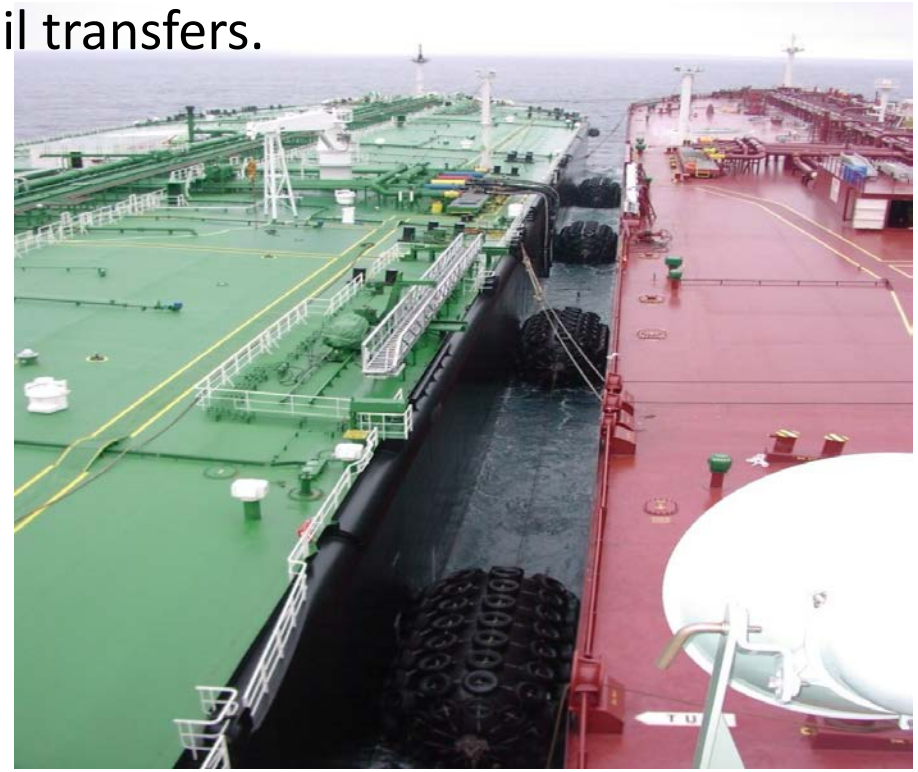
Moving to the Future… Under Keel Clearance Project with PROTIDE:

Stakeholders:

Partners in providing critical weather, wave, and swell information to UKC:

Industry Benefit of the Under Keel Clearance Project – Reduce Offshore Lightering

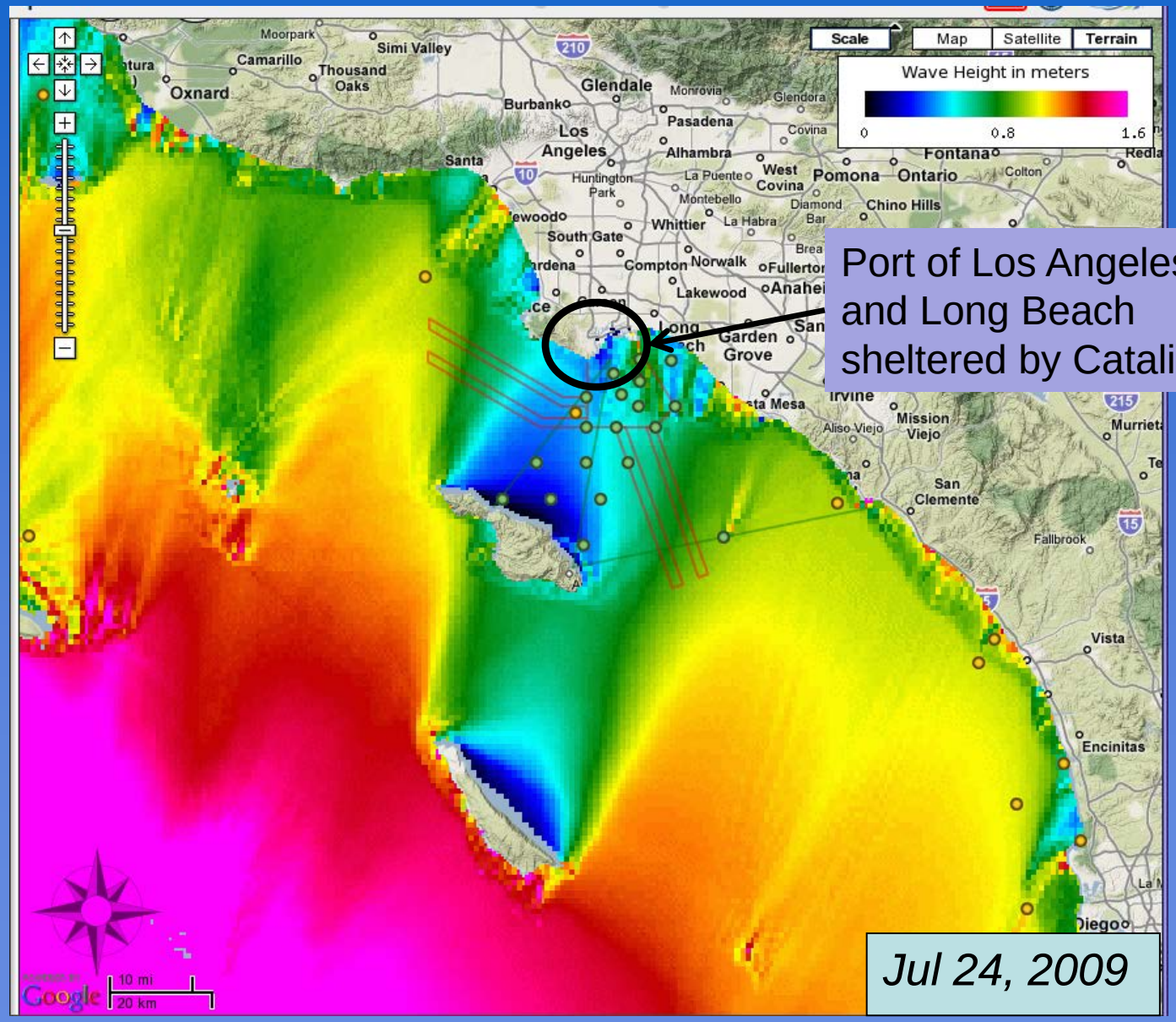
- SAFETY:
  - Reduces overall risk of transporting oil on West Coast (50% of California's oil comes from the Port of Long Beach)
  - Reduced personnel injury/exposure for the line handlers; Lessens crew man hours in demanding operations.
- Economics: $100,000 - $200,000 per day to keep a tanker offshore
- Environment: Reduces oil spill risk by requiring fewer oil transfers.
- Efficiency: Eliminates additional tanker needs.



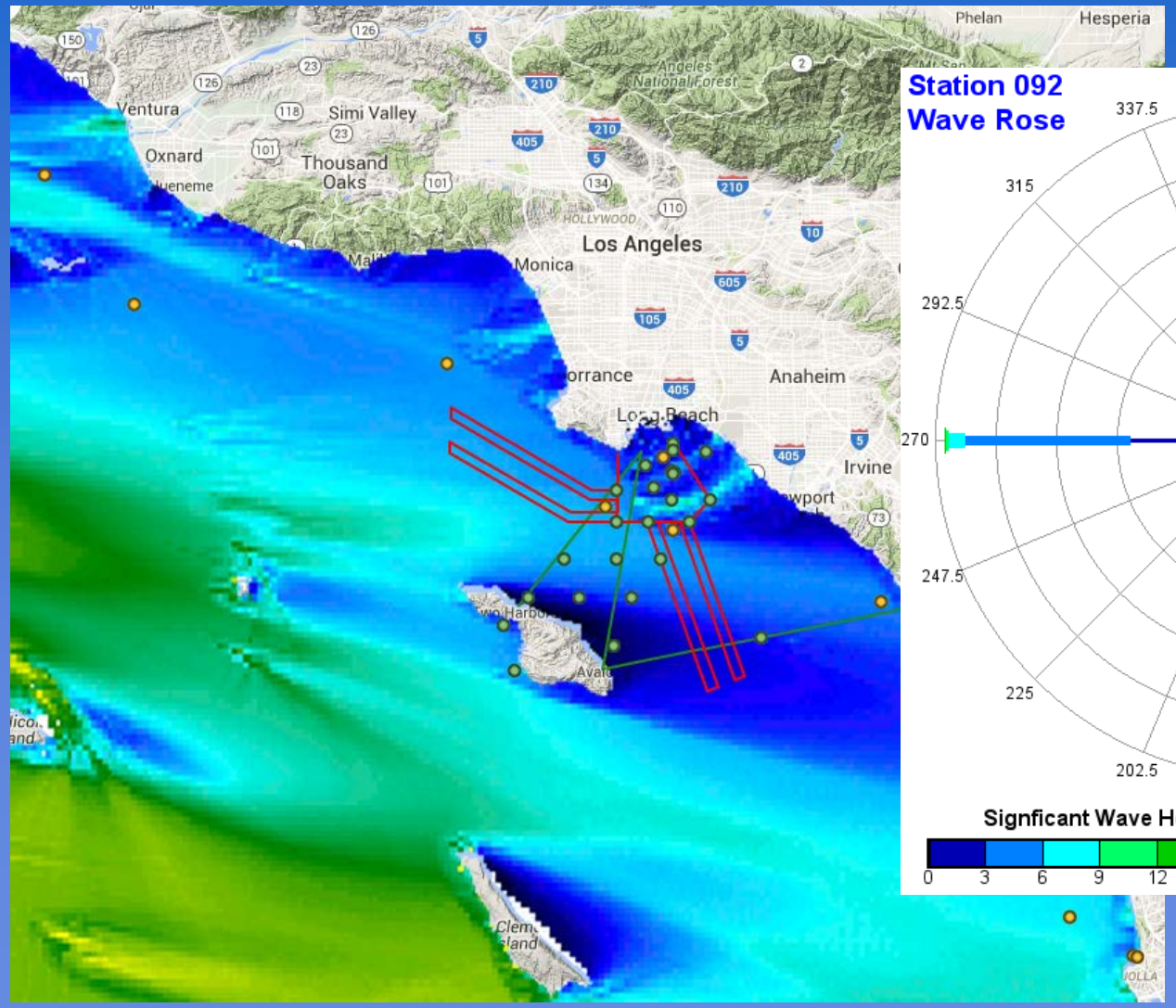
Challenges of developing a wave model for Southern California

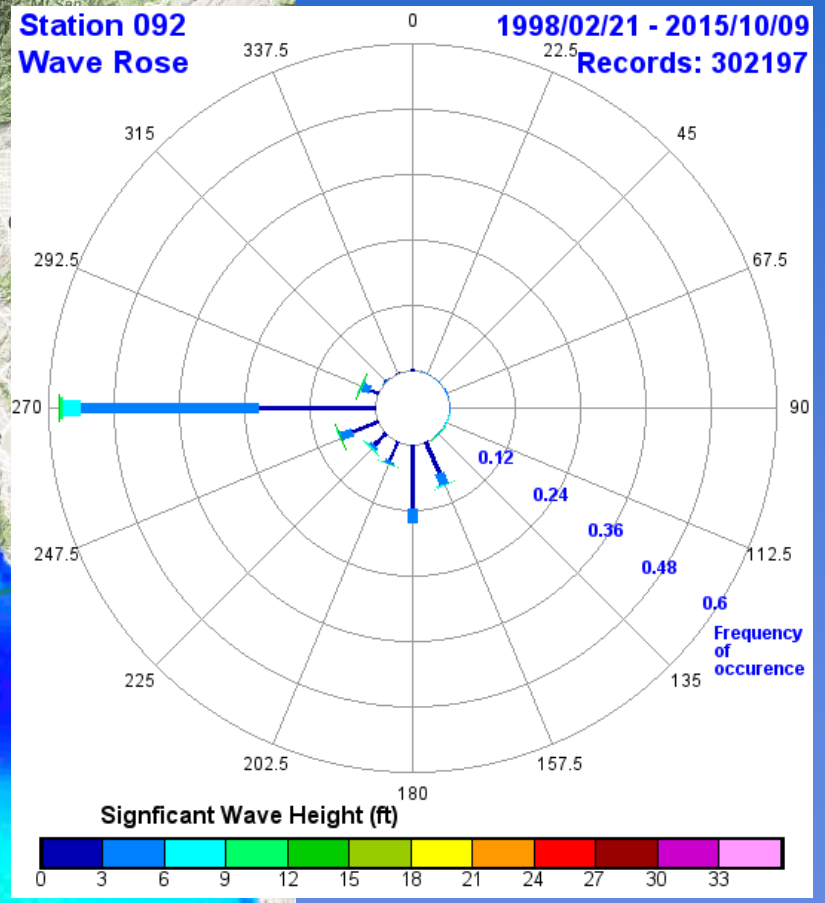
Spatial variation due to island shadowing and deep water canyons allows coastal variability.

Wave heights differ according to direction of the waves.

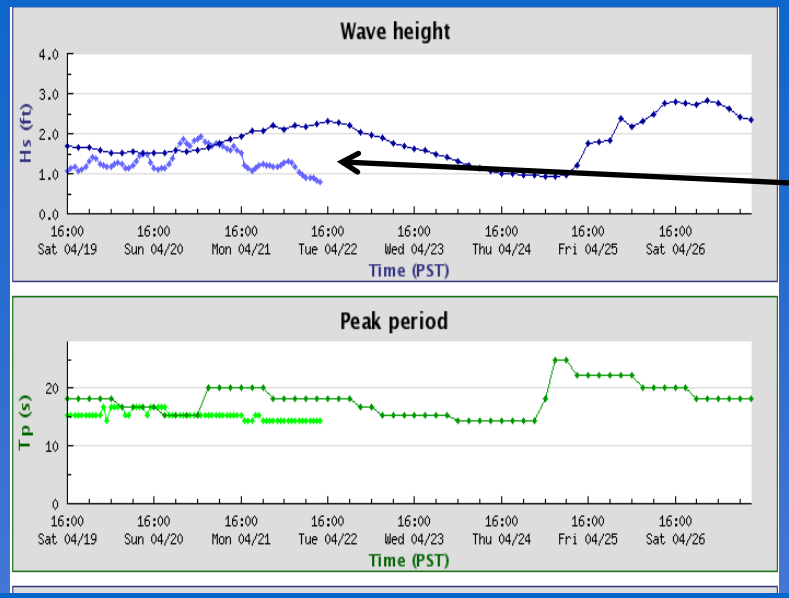


Full Directional Wave exposure for San Pedro buoy (1998-present)





Predominantly Due West!



Wave Watch III Model is over predicting by >1 ft Significant Wave height.

Prediction site: SP018

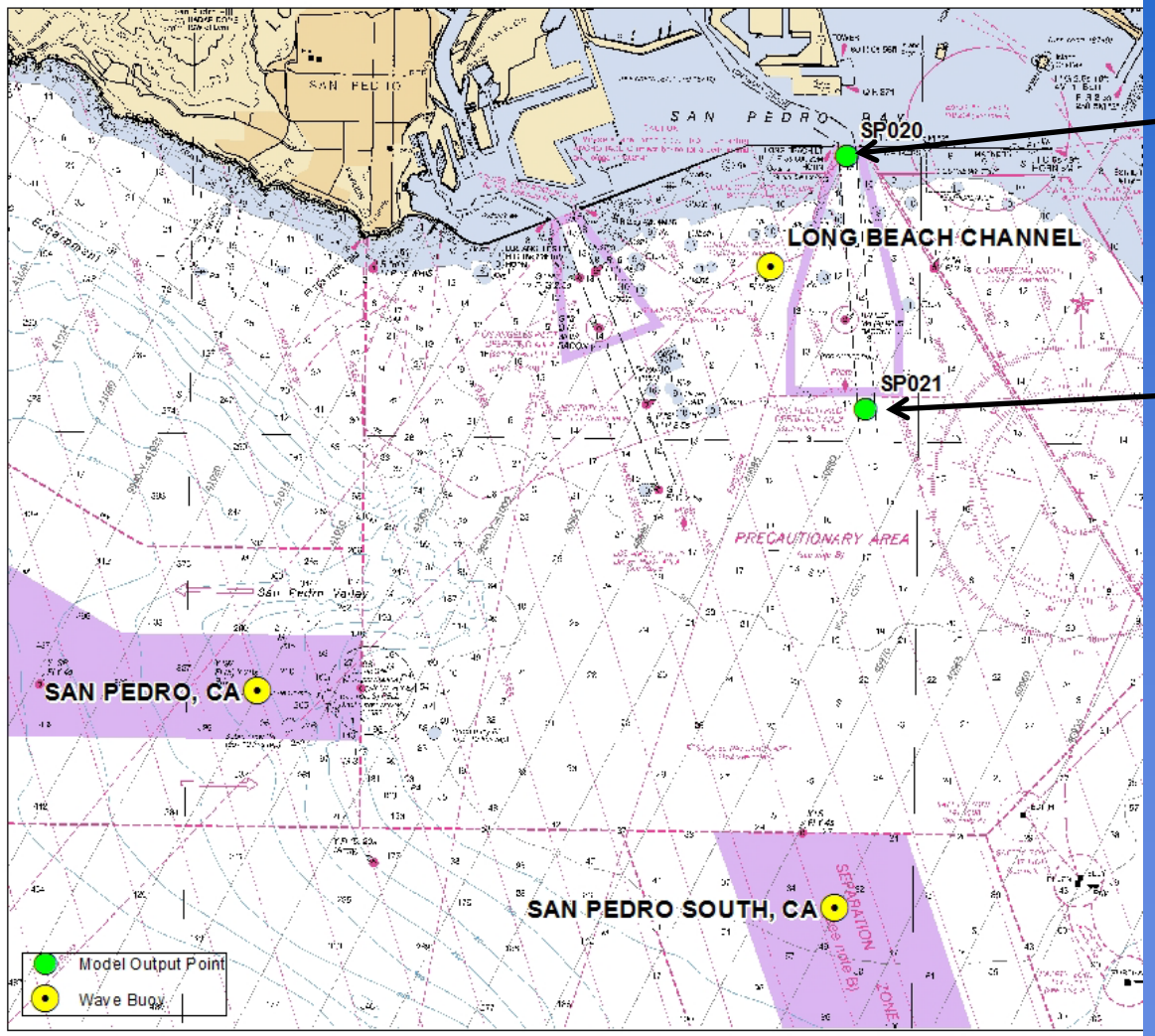
Date (PST)	14+ Hs (ft)	14+ Tp (secs)	14+ Dp (deg T)	Tot Hs (ft)	Tot Tp (secs)	Tot Dp (deg T)
2015-03-25 04:00 pm	2.82	18.18	175	3.18	18.18	175
2015-03-25 07:00 pm	2.85	18.18	175	3.28	18.18	175
2015-03-25 10:00 pm	2.89	16.67	173	3.41	16.67	173
2015-03-26 01:00 am	2.85	16.67	173	3.38	16.67	173
2015-03-26 04:00 am	2.82	16.67	173	3.25	16.67	173
2015-03-26 07:00 am	2.82	16.67	173	3.18	16.67	173
2015-03-26 10:00 am	2.72	15.38	173	3.05	15.38	173

San Pedro Buoy observation vs WW3 Model Predictions - Messaging to Jacobsen Pilots & MX SoCal

- Fortunately, talented people at the National Climate Prediction Centers (NCEP) are developing a *Nearshore Wave Prediction System* model for the San Pedro Bight.

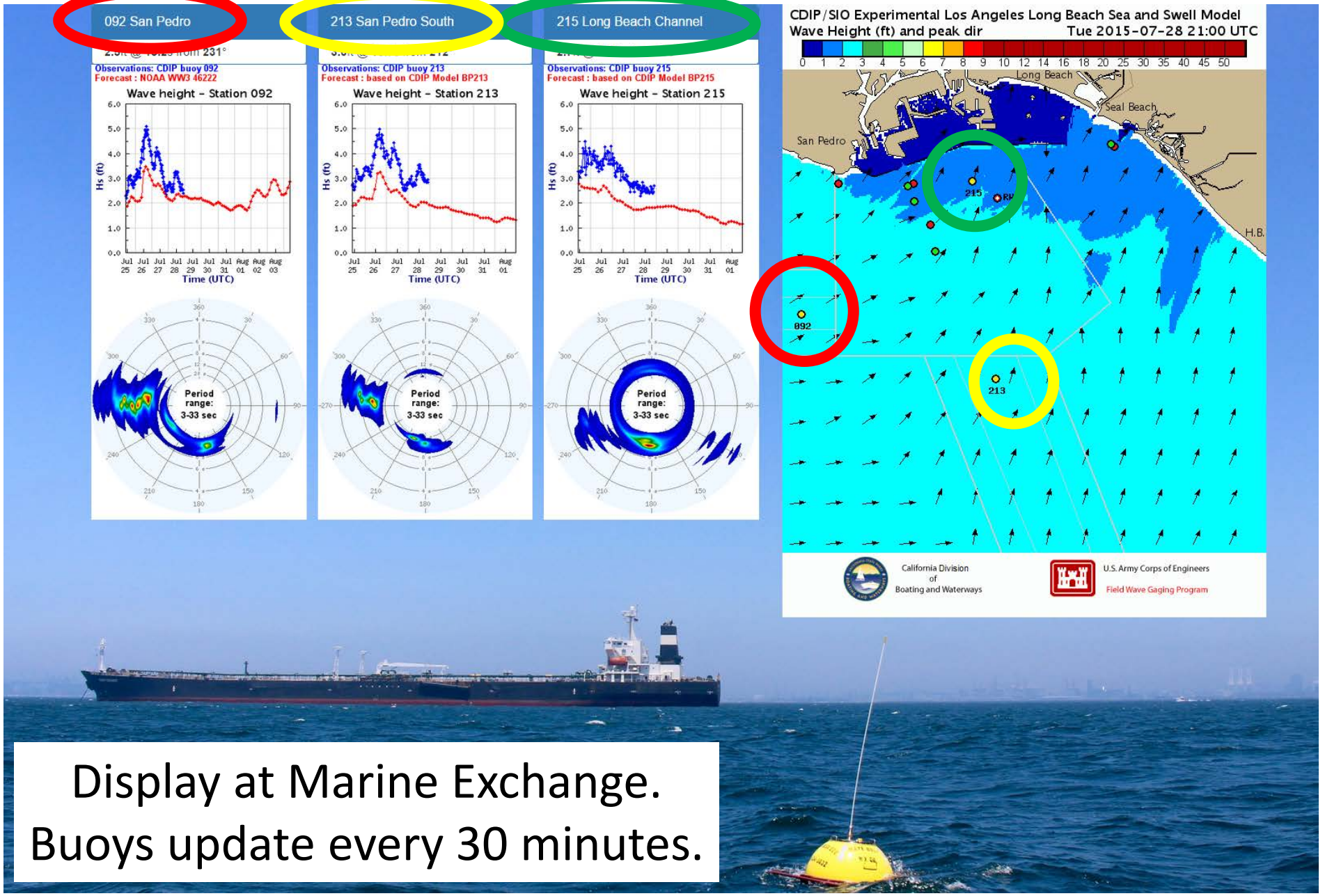
- While this model is being developed and validated, PROTIDE is using the CDIP wave model.

3 wave buoys support the UKC project.
CDIP Wave model locations identified.
Hourly submission to ProTide.



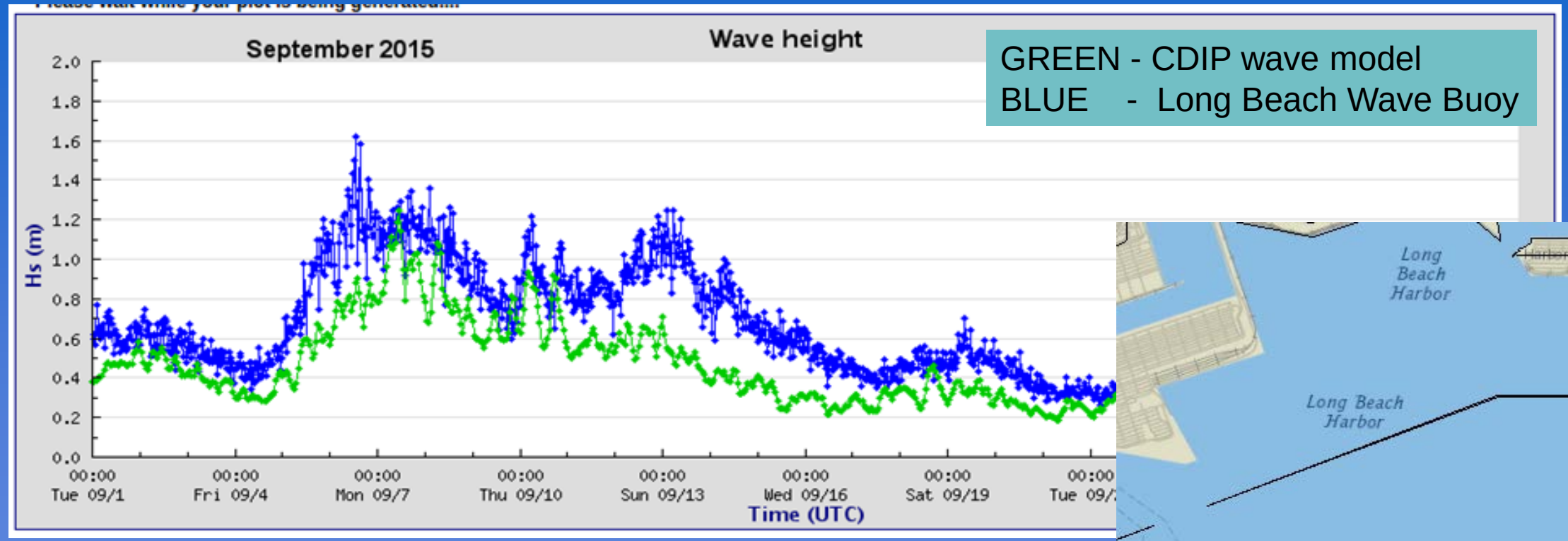
SP020
68.27 ft depth

SP021
83.20 ft depth



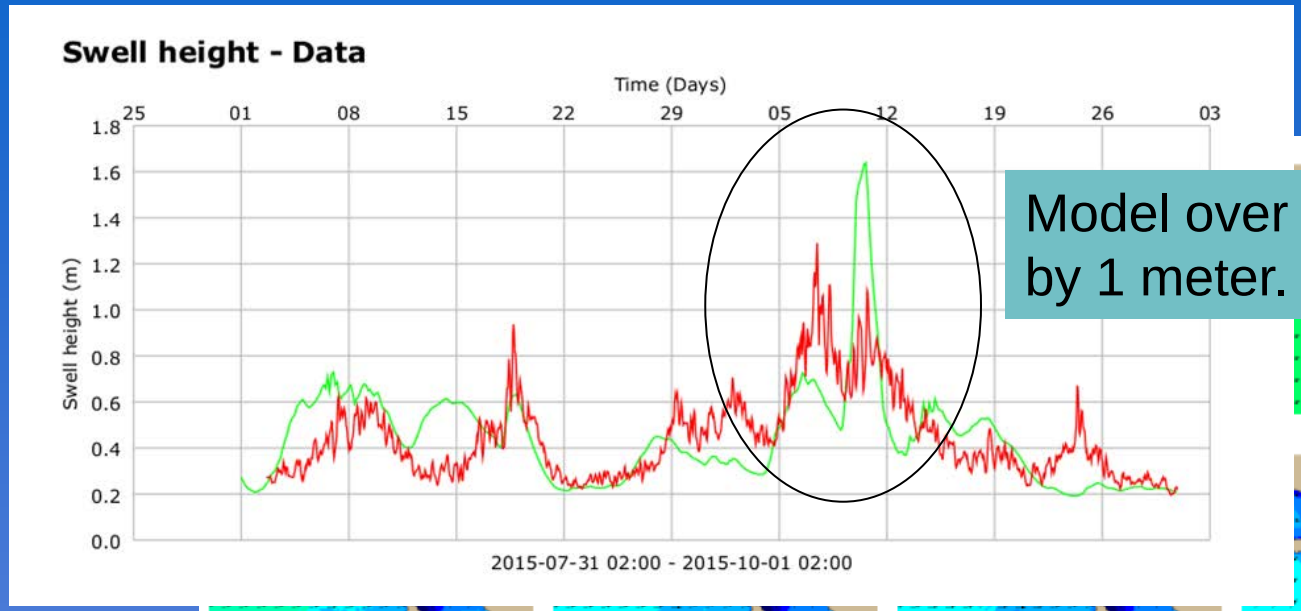
Display at Marine Exchange.
Buoys update every 30 minutes.

- CDIP model underprediction of long period swell highly pronounced due to reflection from the Long Beach breakwater.

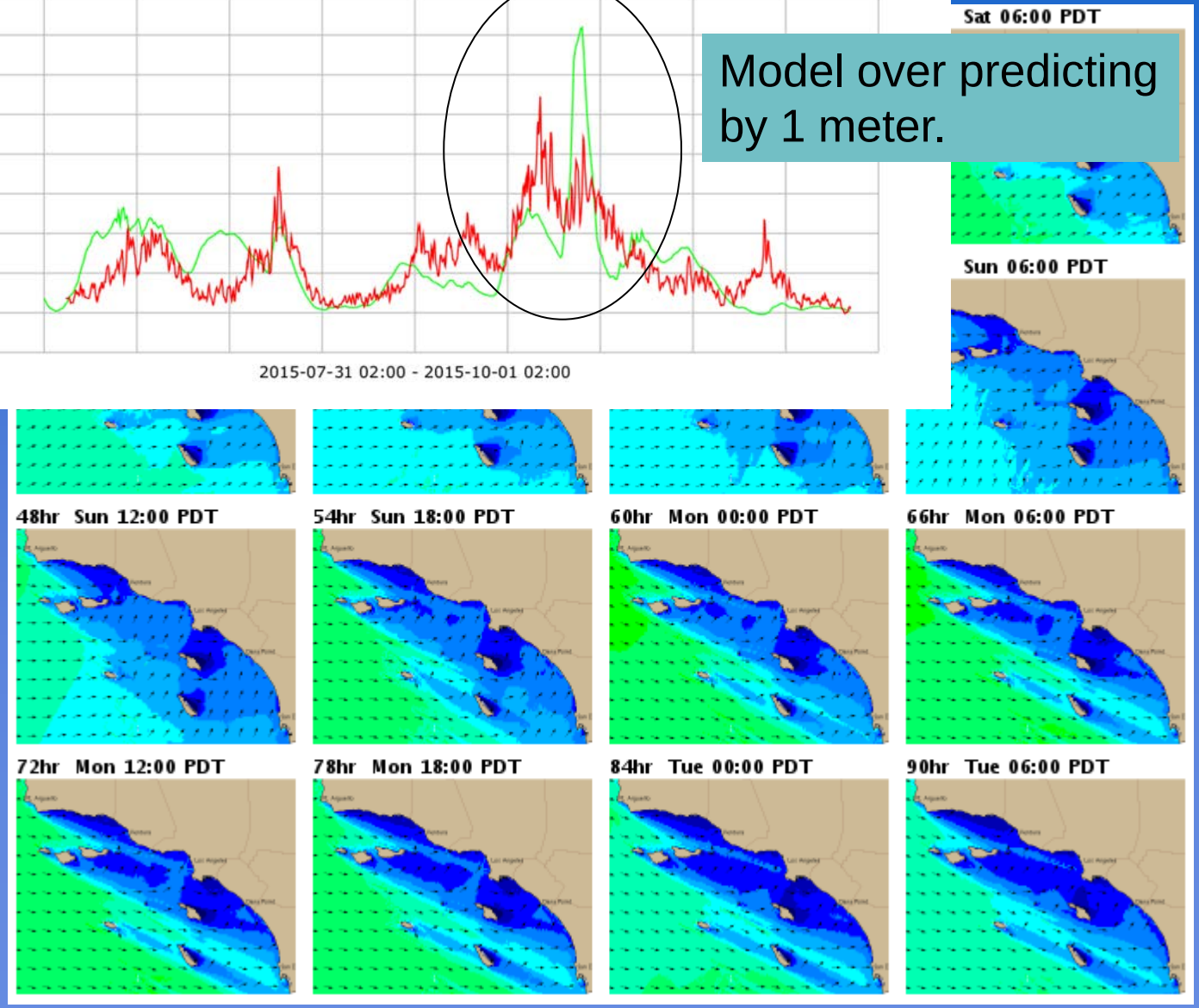


GREEN - CDIP wave model
BLUE - Long Beach Wave Buoy

Buoy observations (red) and CDIP forecast wave model output (green) driven by WWIII.



Model over predicting by 1 meter.



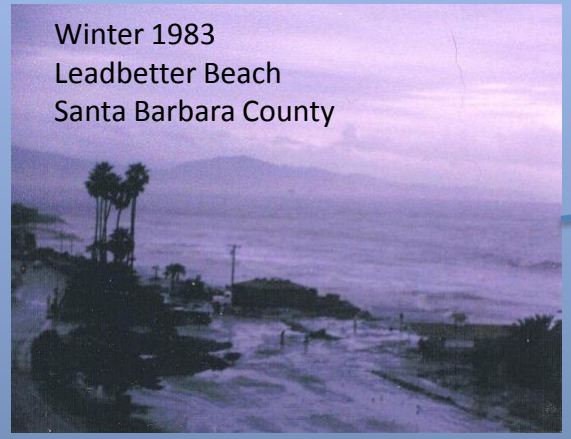
Observation validation is a work in progress!

Accuracy of Under Keel Clearance is critical for safety of humans and vessel transits.

MODELS need to be tested under all conditions (Approximately 1 year of wave heights and wave directions).

CASE STUDY TWO:

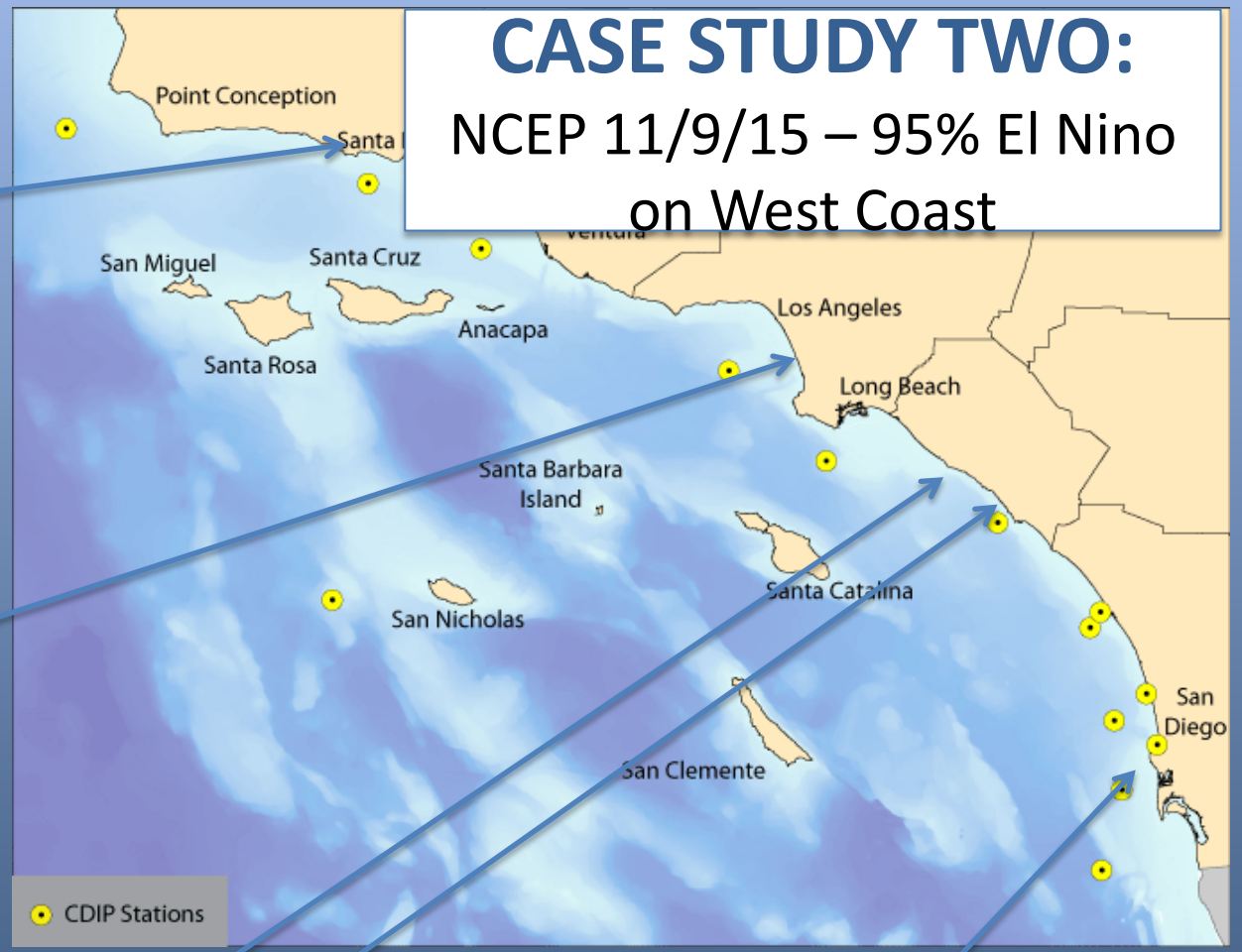
NCEP 11/9/15 – 95% El Nino on West Coast



Winter 1983
Leadbetter Beach
Santa Barbara County

Winter 1983
Venice Beach
Los Angeles County

Winter 1988
Huntington Beach
Orange County



Winter 1997
Costa Mesa
Orange County

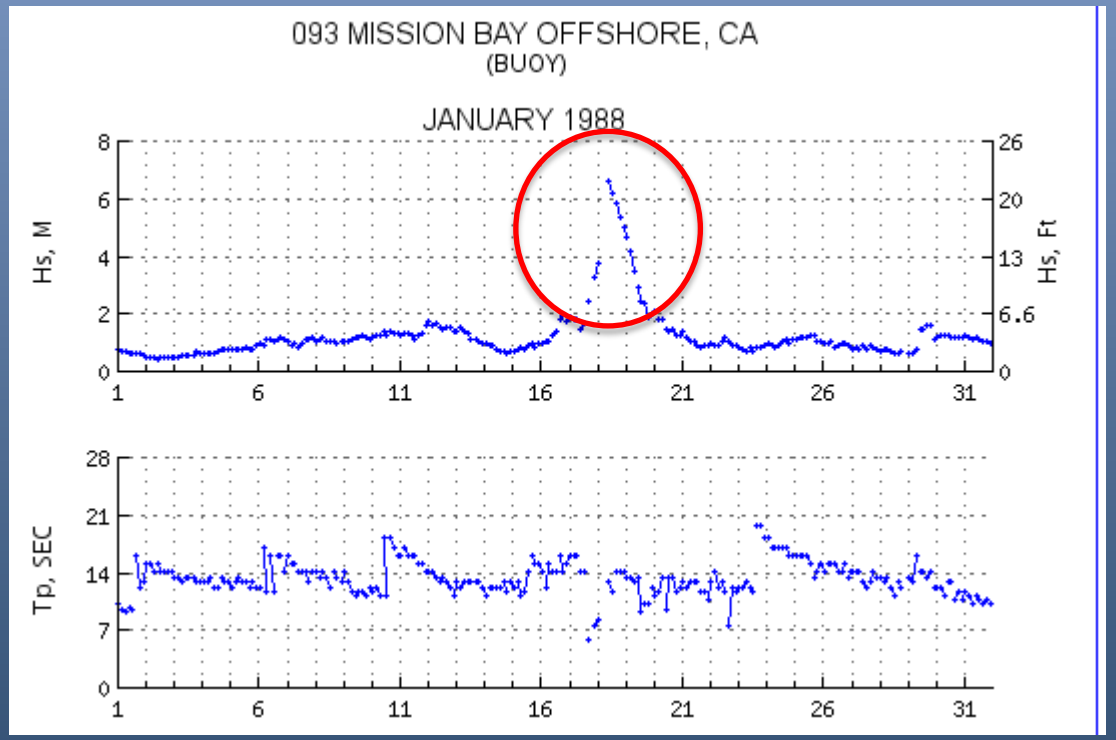
Winter 1983
Marine Room
San Diego County

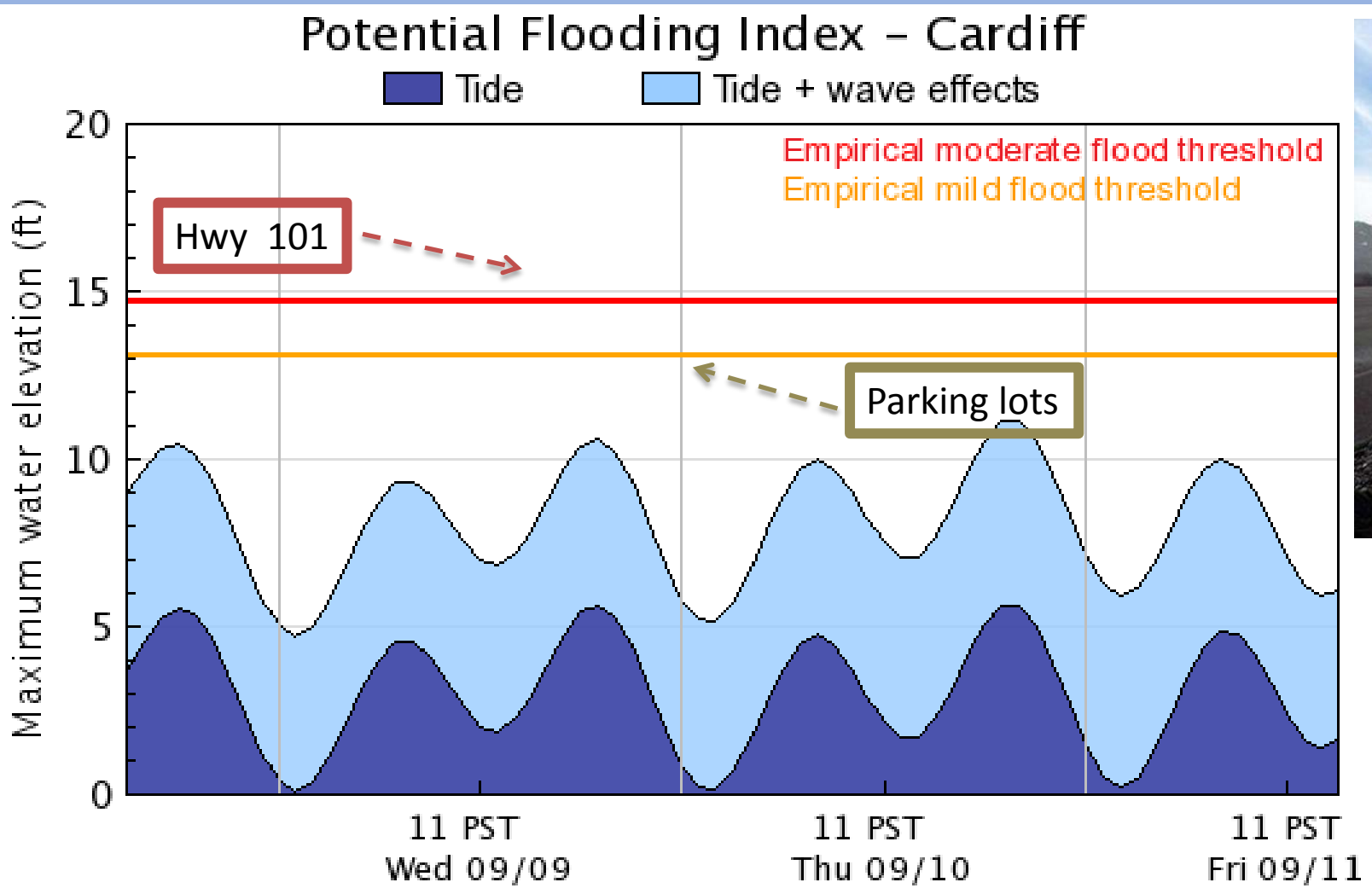
CDIP *Historic Database*

Maximum Significant Wave Height

Mission Bay, CA

Date (PDT)	Hs (ft)	Tp (s)	Ta (s)	Dp (deg)	SST (F)
1988-01-18 02:53	21.78	12.80	10.16		
1988-01-18 05:29	20.28	11.64	9.95		
1988-01-18 08:53	19.06	14.22	9.88		
1988-01-18 11:29	17.65	14.22	10.11		
2006-12-27 20:59	16.57	9.88	8.28	290	59.0
1988-01-18 14:54	16.54	14.22	9.69		
1995-01-04 19:56	16.27	8.00	7.25		
2006-12-27 18:29	15.75	9.09	7.63	297	59.4
2010-01-21 17:54	15.45	15.38	8.37	277	59.4
1998-02-04 00:58	15.35	8.33	7.98	276	63.5
1988-01-18 17:29	15.29	13.47	9.09		
2010-01-21 12:54	15.29	9.09	8.12	189	59.2
2010-01-21 13:24	15.29	16.67	8.42	275	59.2
2009-04-15 01:54	15.26	10.53	8.18	289	57.6
2010-01-21 13:54	15.22	9.09	8.15	206	59.4
1995-01-04 22:56	15.22	8.00	7.68		
2006-12-27 21:29	15.16	10.53	8.28	280	59.0
1998-02-04 00:28	15.12	9.88	7.92	230	63.5
2010-01-21 12:24	15.12	9.09	8.29	190	59.2
2006-12-27 18:59	15.09	9.88	7.91	288	59.4
2010-01-21 14:54	14.67	15.38	8.28	280	59.4
2010-01-22 07:54	14.67	9.88	8.38	248	59.2
2009-12-07 22:24	14.67	9.09	7.10	234	60.3
2006-12-27 17:59	14.63	9.09	7.51	297	59.4
2010-01-21 18:54	14.60	14.29	8.59	283	59.4





Cardiff 3 DAY WATER LEVEL FORECAST (Updates hourly)

Cardiff Water Levels and Thresholds Explained

High waves and tides at Cardiff, CA occasionally flood adjacent parking lots, and less frequently impacts traffic on the bordering Highway 101 (Figure 1). CDIP water level (WL) forecasts at Cardiff include flooding thresholds (Figure 2), lacking at other CDIP WL sites. Additionally, the WL forecasts use a relationship between offshore waves and wave runup that is calibrated with recent site specific observations.

Wave effects formula: The superelevation of the shoreline runup water level (WL) on steep beaches is generally underestimated by the Stockdon et al (2006) formula for dissipative beaches

$$WL = 0.043\ (HoLo)^{1/2} \quad (1)$$

(1) is used for CDIP water levels at all sites except Cardiff. Sections of Cardiff beach have recently been relatively wide and steep, because of a nourishment in fall 2012 (sand brought to the beach from offshore, Figure 3). A Stockdon et al (2006) formula, valid on steep beach faces with slope β_f , is

$$WL = 1.1\left(0.35\beta_f (H_0 L_0)^{1/2} + \frac{[H_0 L_0 (0.563\beta_f^2 + 0.004)]^{1/2}}{2}\right). \quad (2)$$

With a representative Cardiff slope $\beta_f = 0.07$ (Figure 4), eq (2) yields

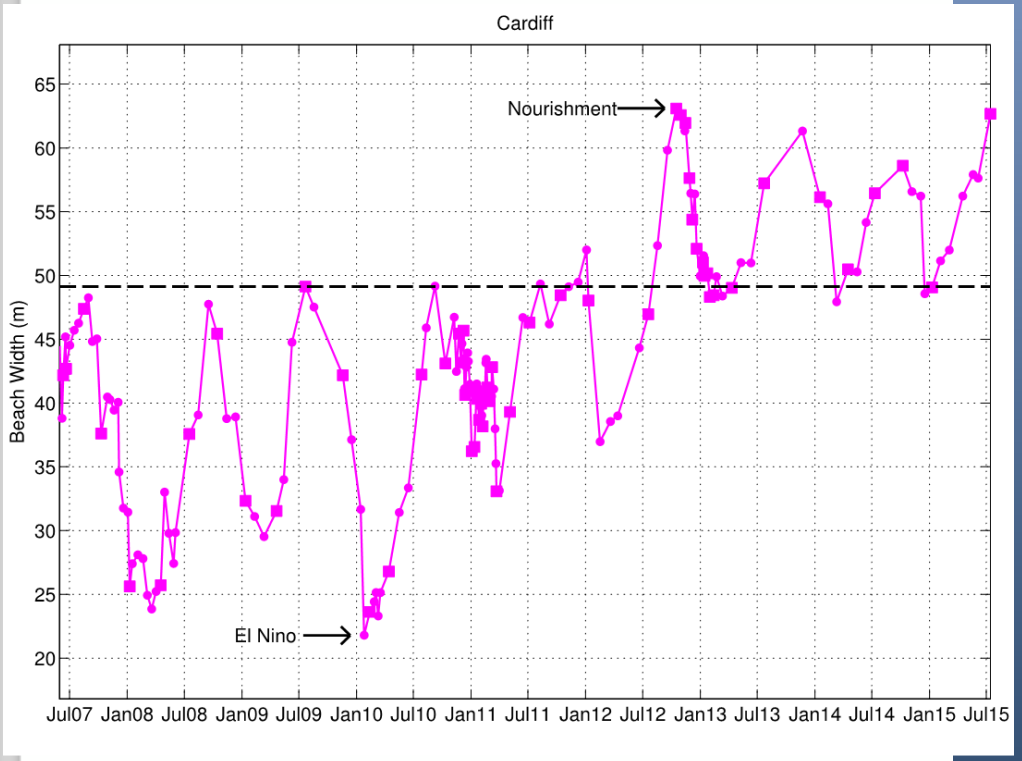
$$WL = 0.08\ (HoLo)^{1/2} \quad (3)$$

about twice as large as (eq 1). These simplistic formulas (3 and 4) do not include the effects of sand bars, and the variation of beach slope over time (Figure 4). Observations (Figure 5) of overtopping of the nourished berm in January 2013 are used to calibrate an operational water level formula for Cardiff (wave effects in Figure 2)

$$WL = 0.12\ (HoLo)^{1/2} \quad (4)$$

Thresholds: The berm edge elevation is about 3.5m Navd88 (Figure 4). Airborne Lidar and terrestrial elevation surveys were used to map the vulnerable stretch of Highway 101 (Figure 6). The elevations of North and South State Park parking lots are between 3.5-4.0m. The threshold for MILD parking lot flooding is set at 4.0m .
Riprap bordering the beach, that water must overtop to reach 101, typically reaches about 4.5-5.0m. Elevations of the 101 shoulder are as low as 3.5m. The threshold for moderate flooding (101 ponds at low spots) is set at 4.8m. The water level needed to significantly impact Cardiff beach will depend on the width of the remaining protective berm (Figure 4).

Summary Estimates of Cardiff flood thresholds, and the wave conditions for which those thresholds will be reached, are qualitative. The detailed beach profile is not considered, and a single threshold is used for the entire shoreline reach (Figure 6). Numerical modeling and detailed observations (ongoing at Cardiff) are key to improving site-specific predictions of runup, overtopping, and flooding.



http://cdip.ucsd.edu/?nav=documents&sub=faq&xitem=cardiff_wl

Community Engagement for Model Validation

1. Photos that are geo-tagged (lat/long/time)
2. Textual comments: “water was up to my knees!”
3. Additional water level gauge
4. Additional beach level elevations (MOBERM)

Website includes:
Map of flooding index locations
Index of Historical Events (Hs, Tp, Dp, Photos, Comments)

The Marine Room

High Tide Breakfast

"The view only gets better during high tide as the waves crash against our picture windows. Savor a gourmet breakfast buffet and stunning views at this signature San Diego experience."